Crack Growth Retardation Parameter Sensitivity to Thickness of an Aluminum Alloy

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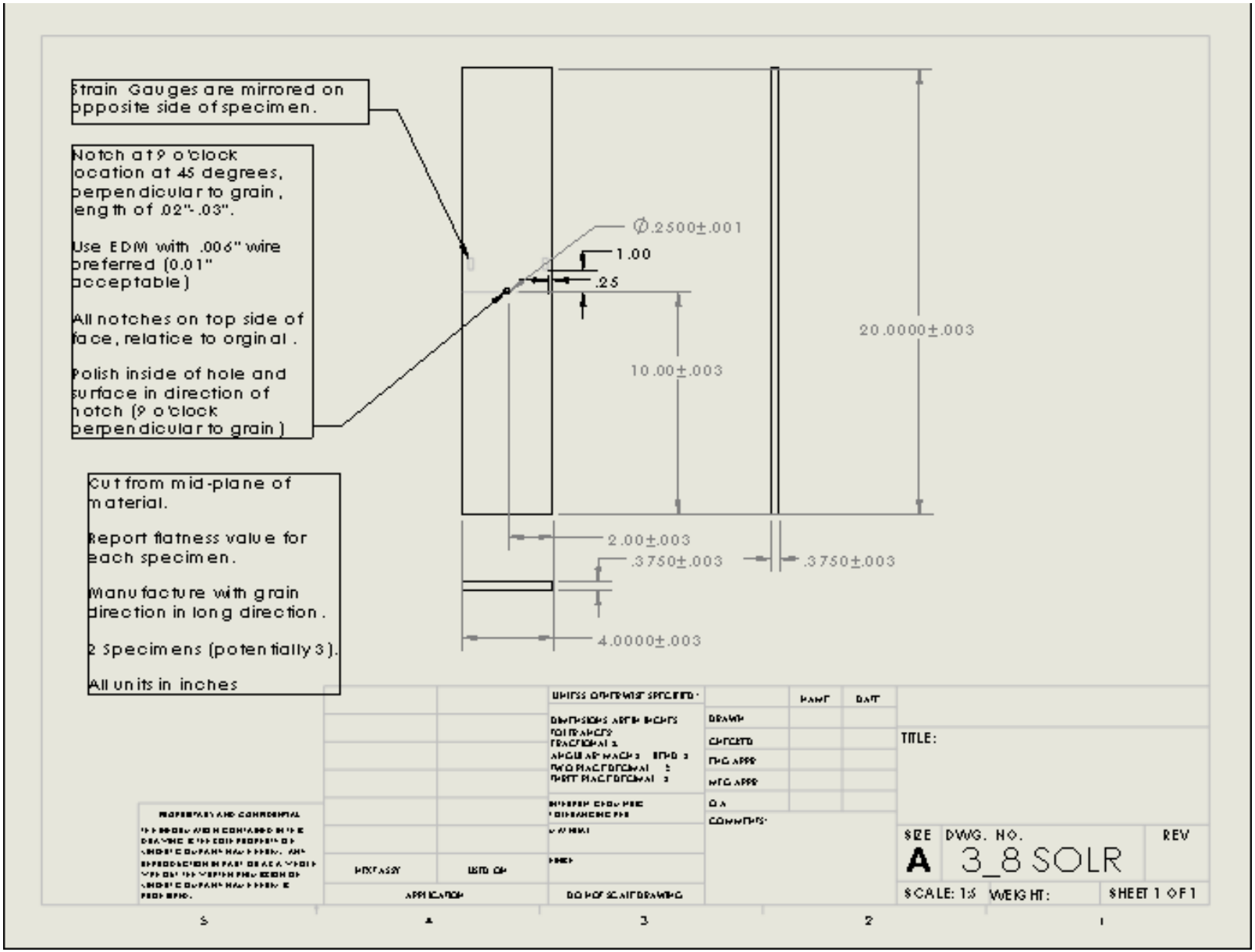
Background

- **This project is trying to isolate the effect of plate thickness on Shut-Off Overload Ratio (SOLR), the retardation parameter in the Willenborg retardation model.**
- **Approach: cut specimens of various thicknesses from the mid-plane of a ¾-inch thick plate of 7075-T7351 material**
  - **Test identical specimens (except for thickness) under spectrum loading**
    - **Rectangular specimen, center hole, corner notch**
  - **Adjust SOLR in AFGROW to obtain a "fit" to experimental test data and see if there is an identifiable trend with thickness**

Outline

- Objective
- Testing
  - Specimen
  - Method
  - Results
- Comparisons
  - Methods Used
  - Trends Identified
- Results
- Post-Test Fractography
- Observations and Trends
- Issues

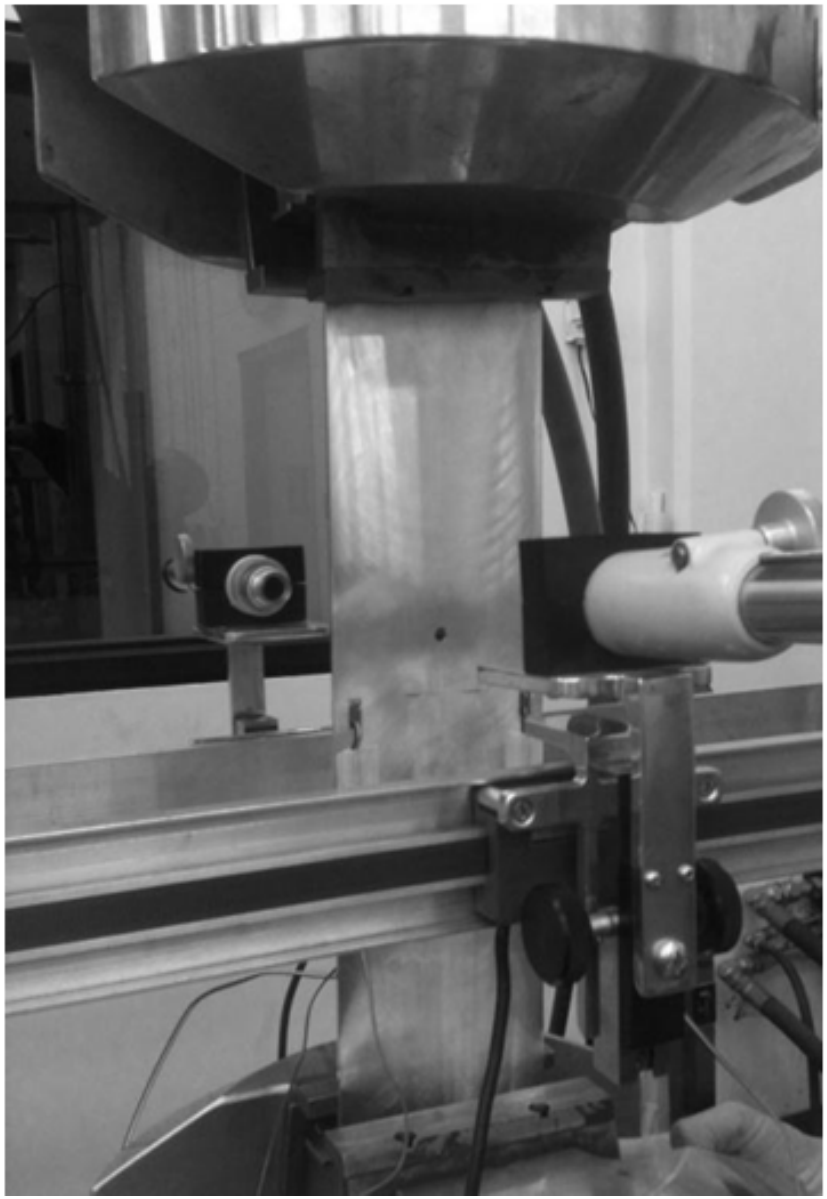
Specimen Geometry



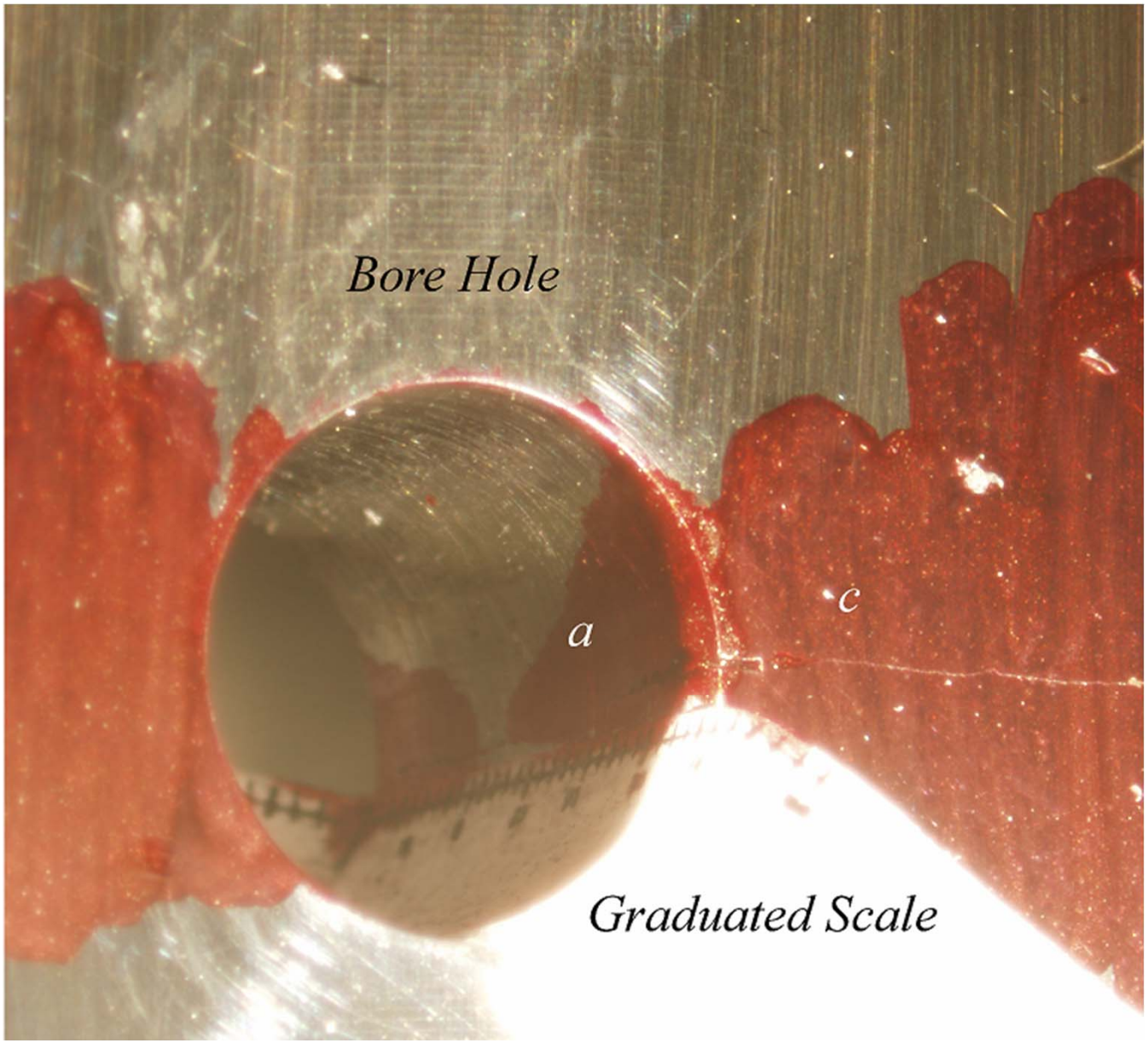
Test Specimen Dimensions

Test	thickness mm, (in)	width mm, (in)
0.125" #1	3.20 (0.126)	101.6 (4.001)
0.125" #2	3.14 (0.1235)	101.6 (4.001)
0.375" #1	9.50 (0.374)	101.7 (4.002)
0.375" #2	9.46 (0.3725)	101.6 (4.001)
0.625" #1	15.85 (0.624)	101.7 (4.005)
0.625" #2	15.72 (0.619)	101.7 (4.003)

Traveling Microscopes



Bore Measurement Scale

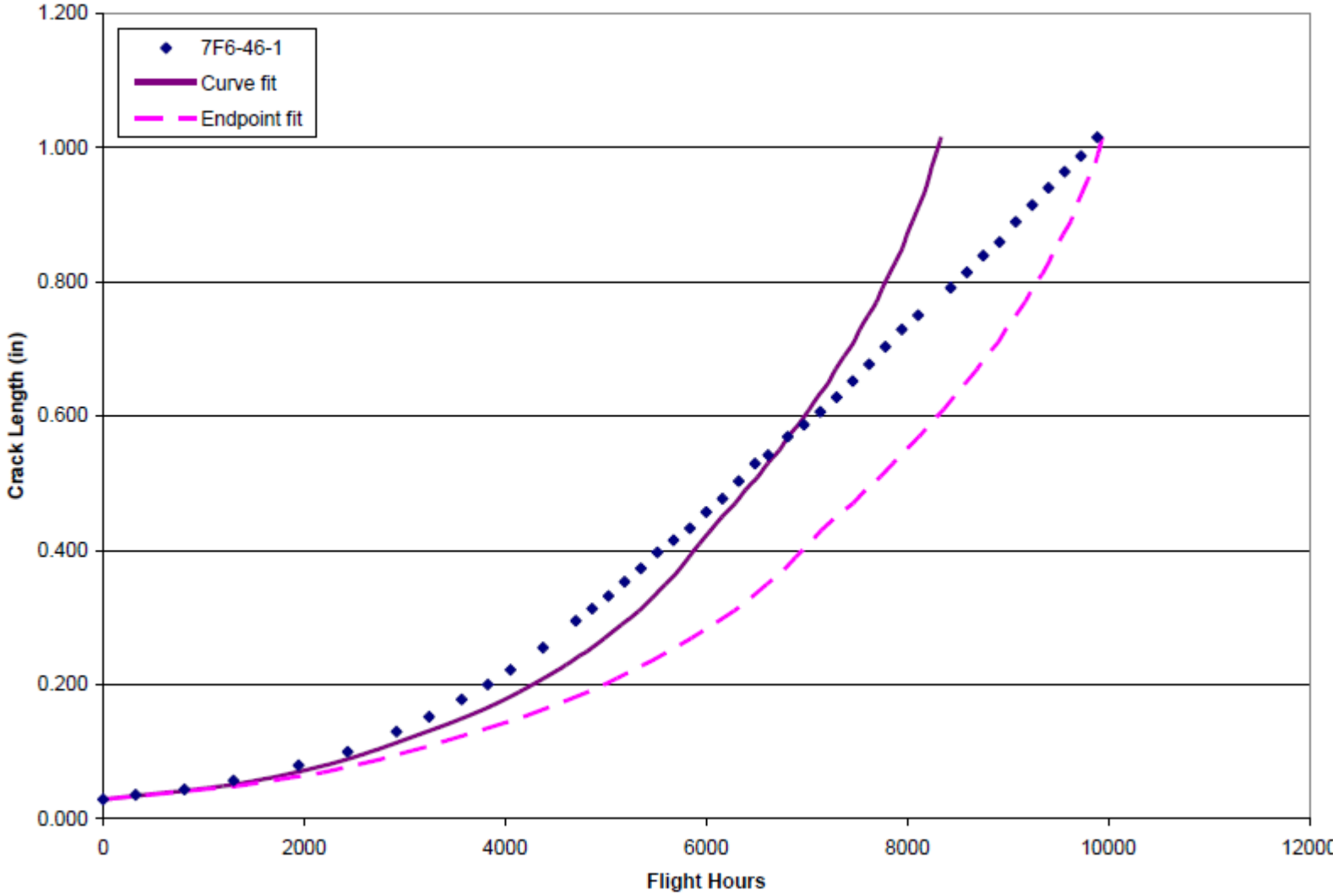


Two Methods

- **Method A - force the analytical model's crack aspect ratios to match the test results**
- **Method B – match the initial crack aspect ratio and allow the aspect ratio to be driven by the *a*- and *c*-direction stress intensity factors during the crack growth prediction**

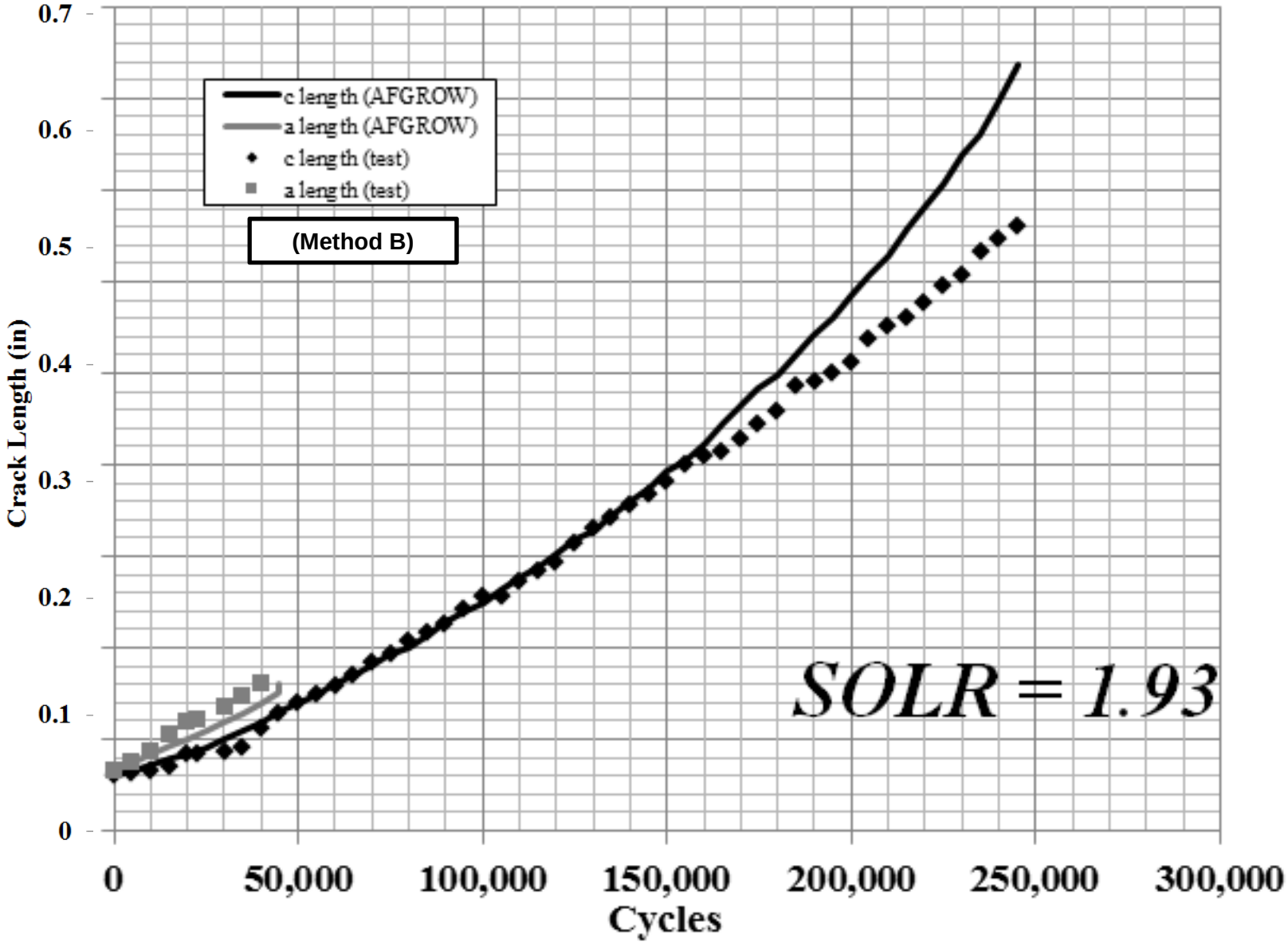
METHOD B

But first…

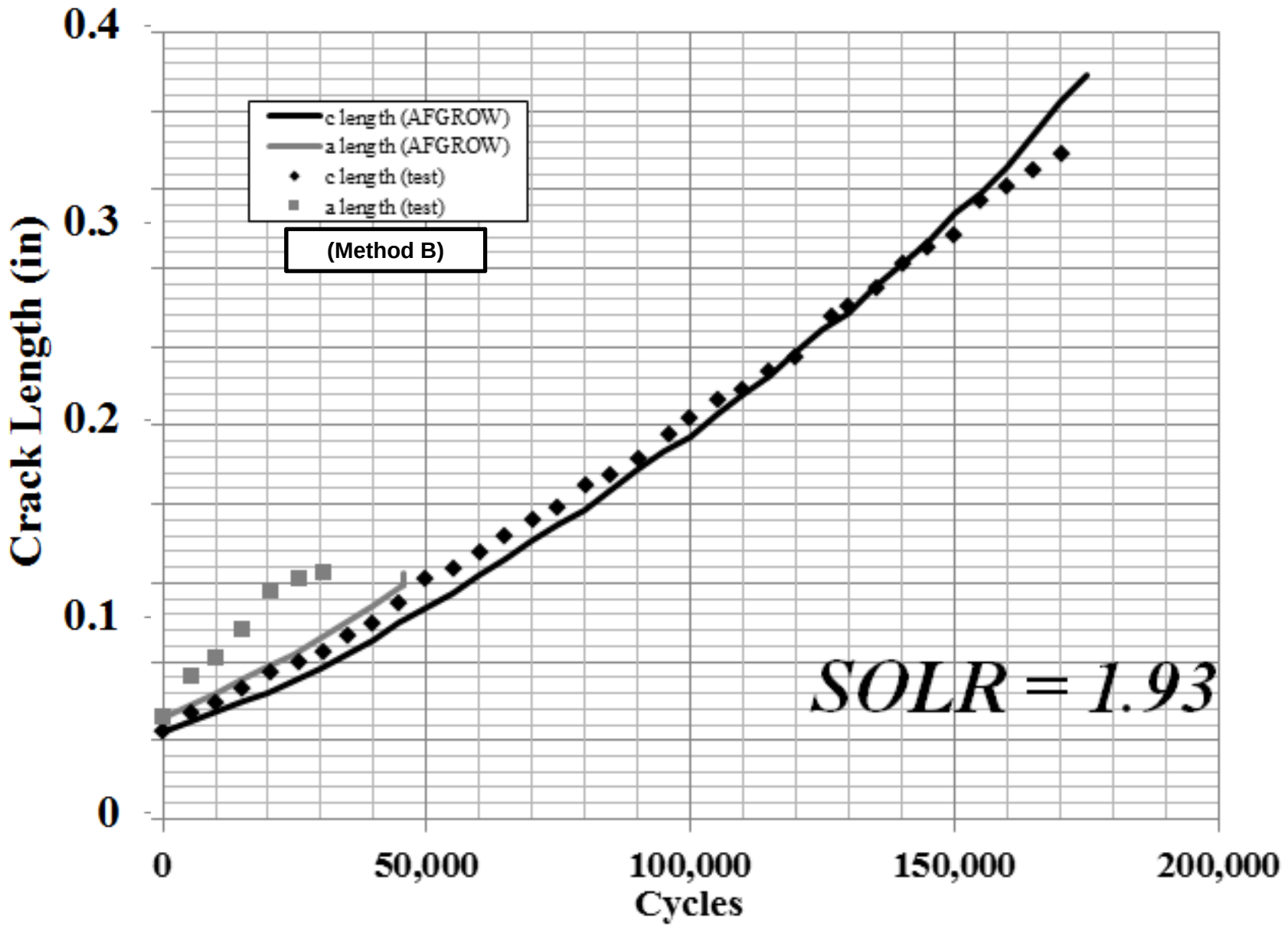


Source: Smith, Luciano, "The Shutoff Overload Ratio and its Sensitivity to Analytical Parameters and Techniques," AFGROW Workshop, 12 September 2012.

1/8-inch Specimen #1



1/8-inch Specimen #2



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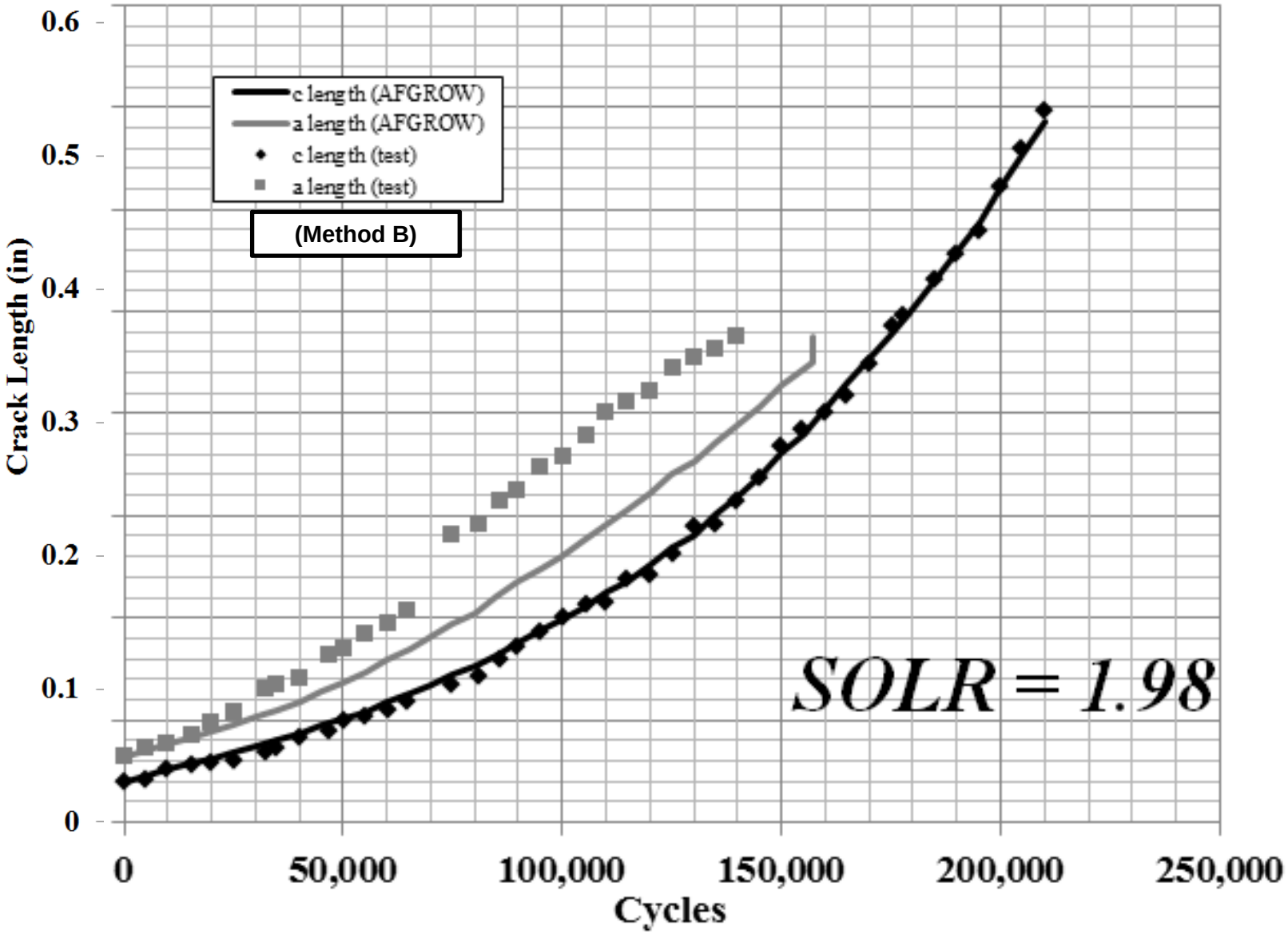

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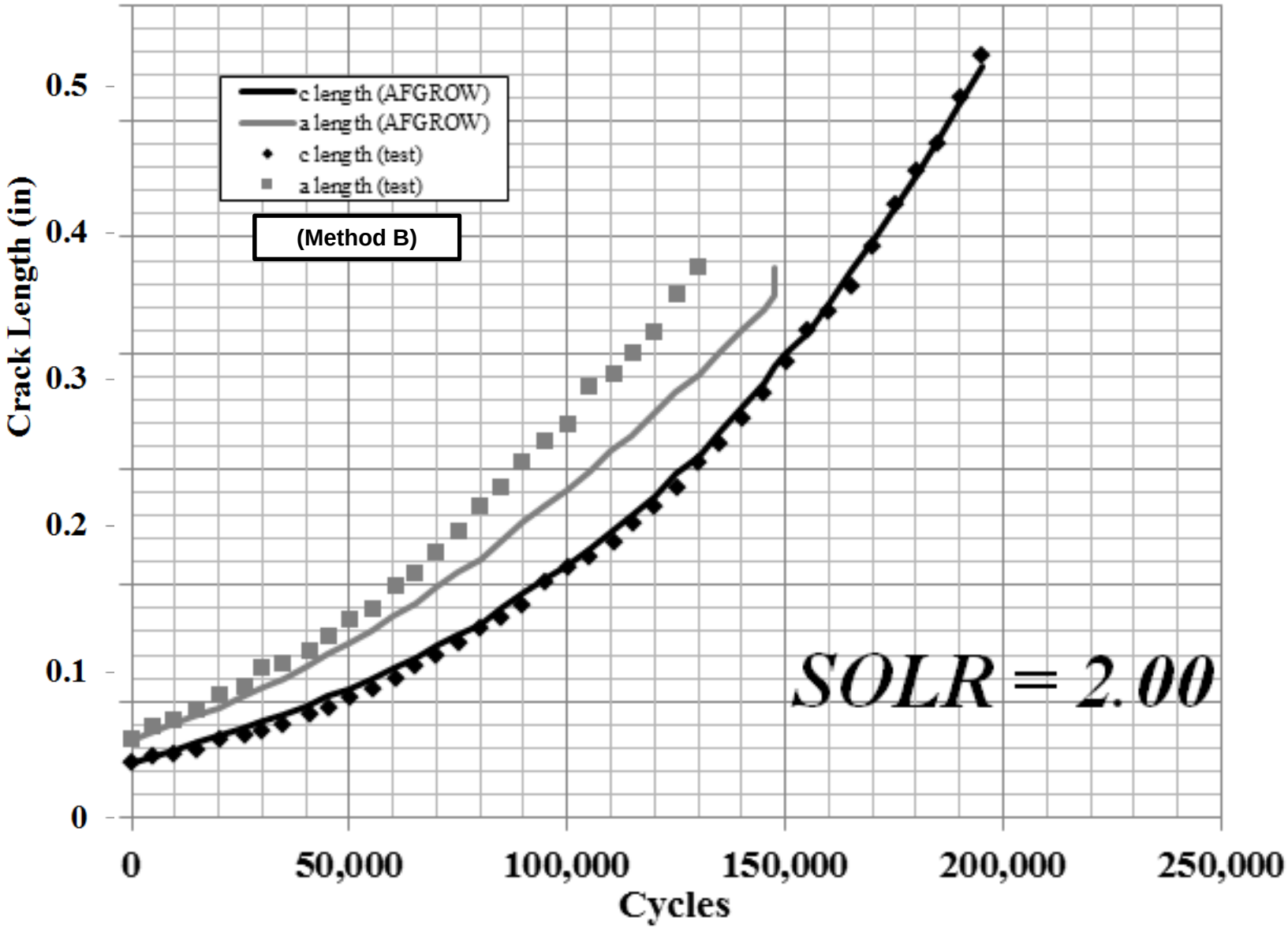
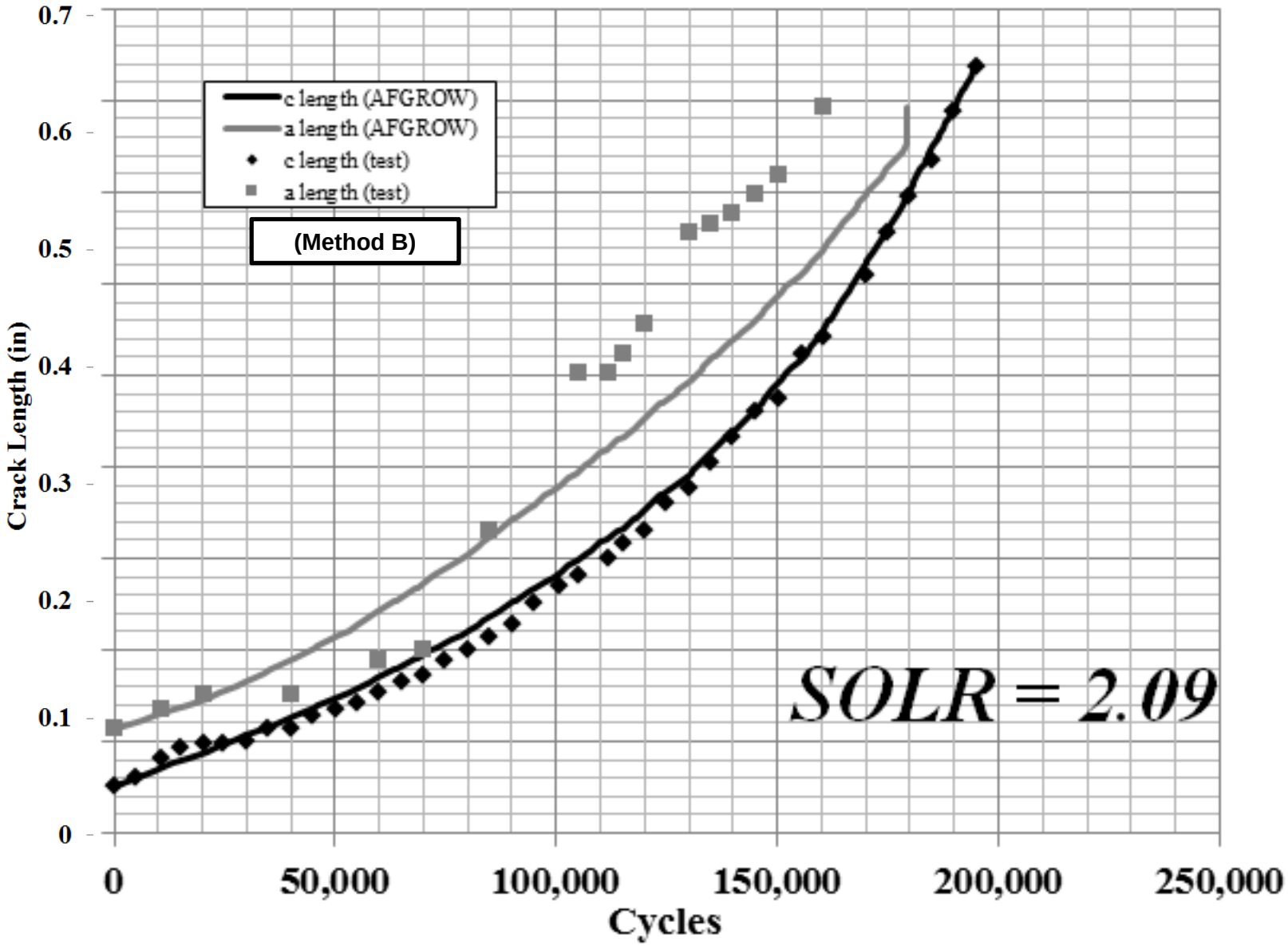
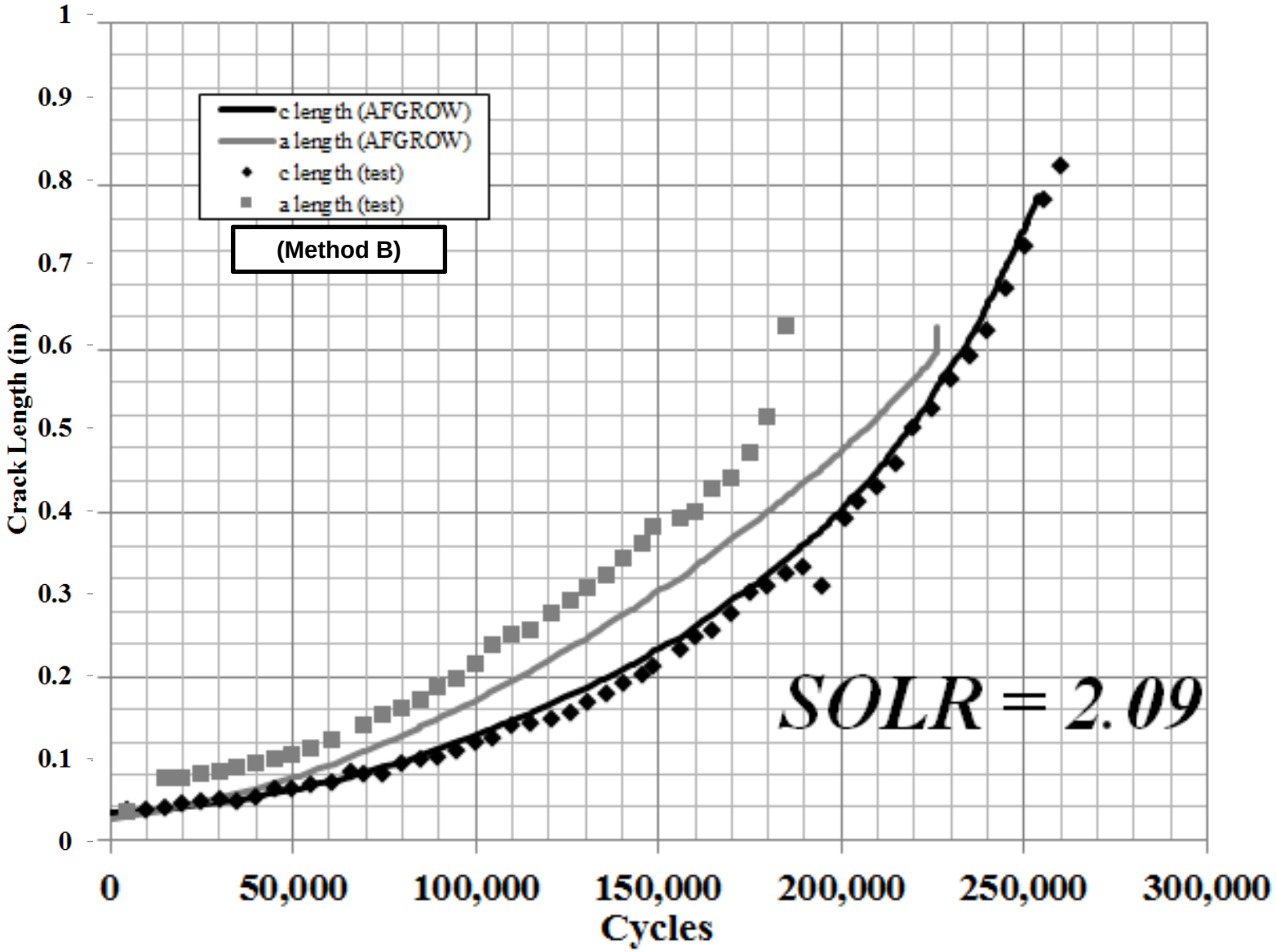


5/8-inch Specimen #1

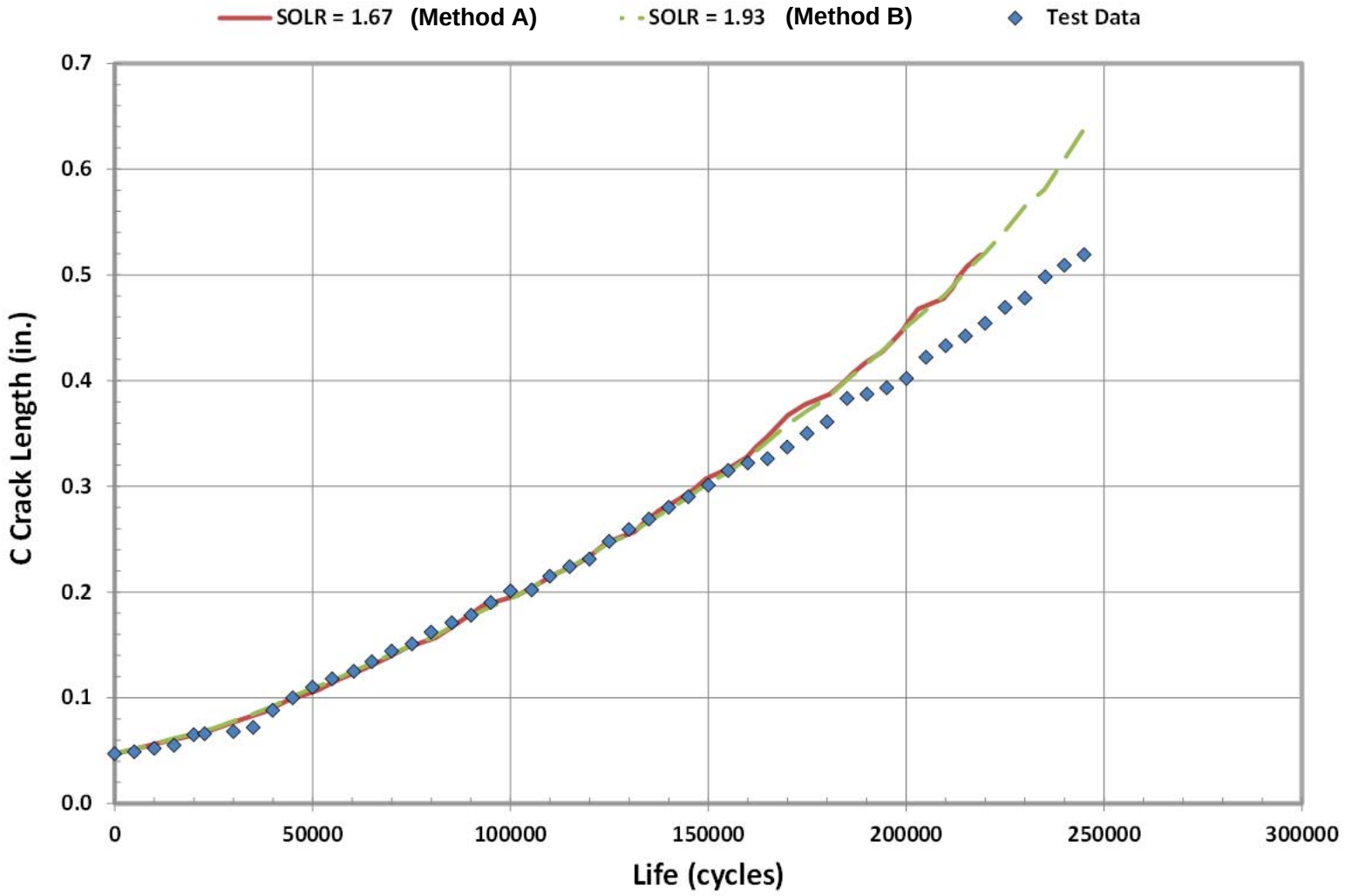


5/8-inch Specimen #2

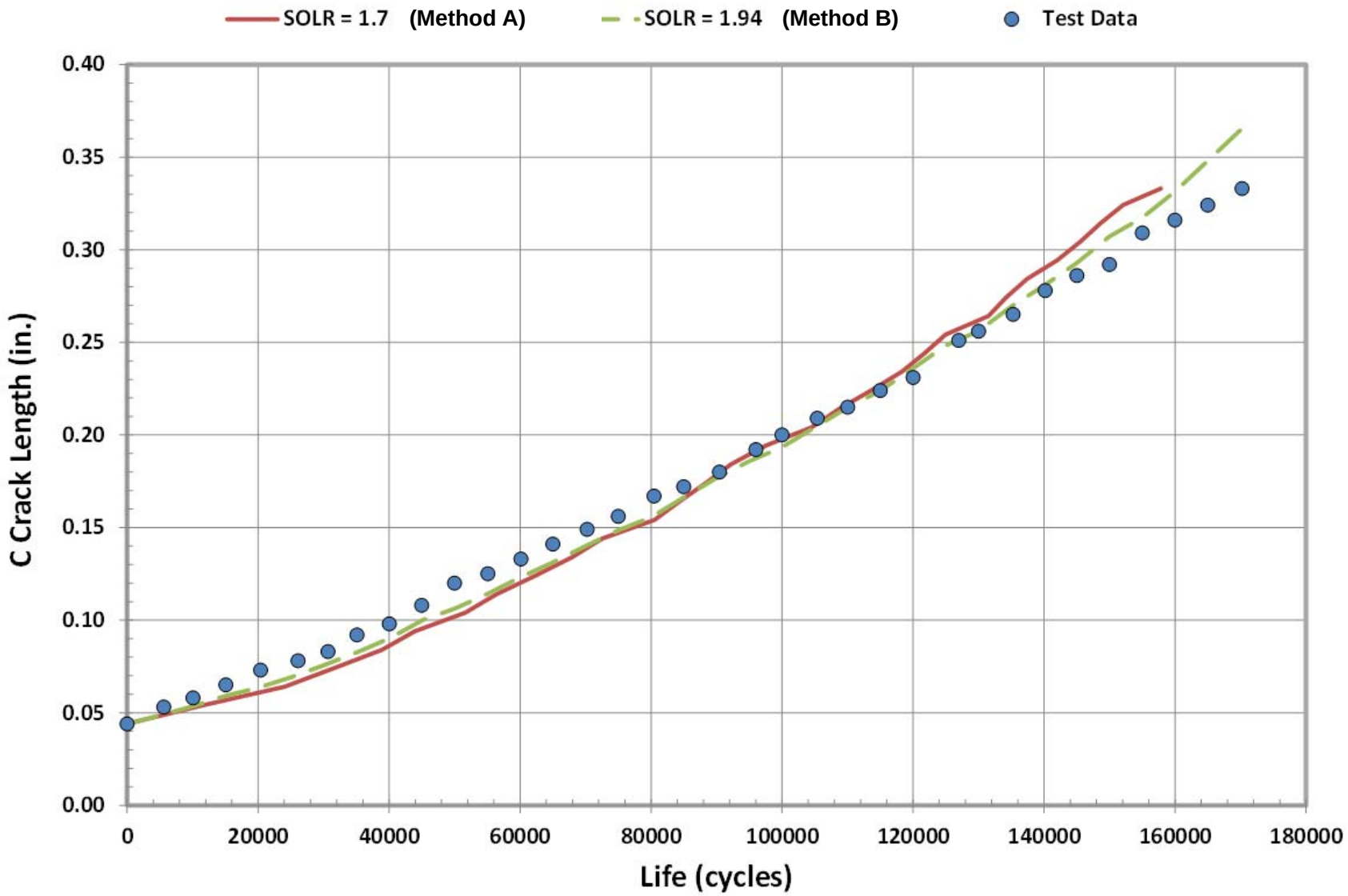


METHODS A AND B

1/8-inch Specimen #1



1/8-inch Specimen #2



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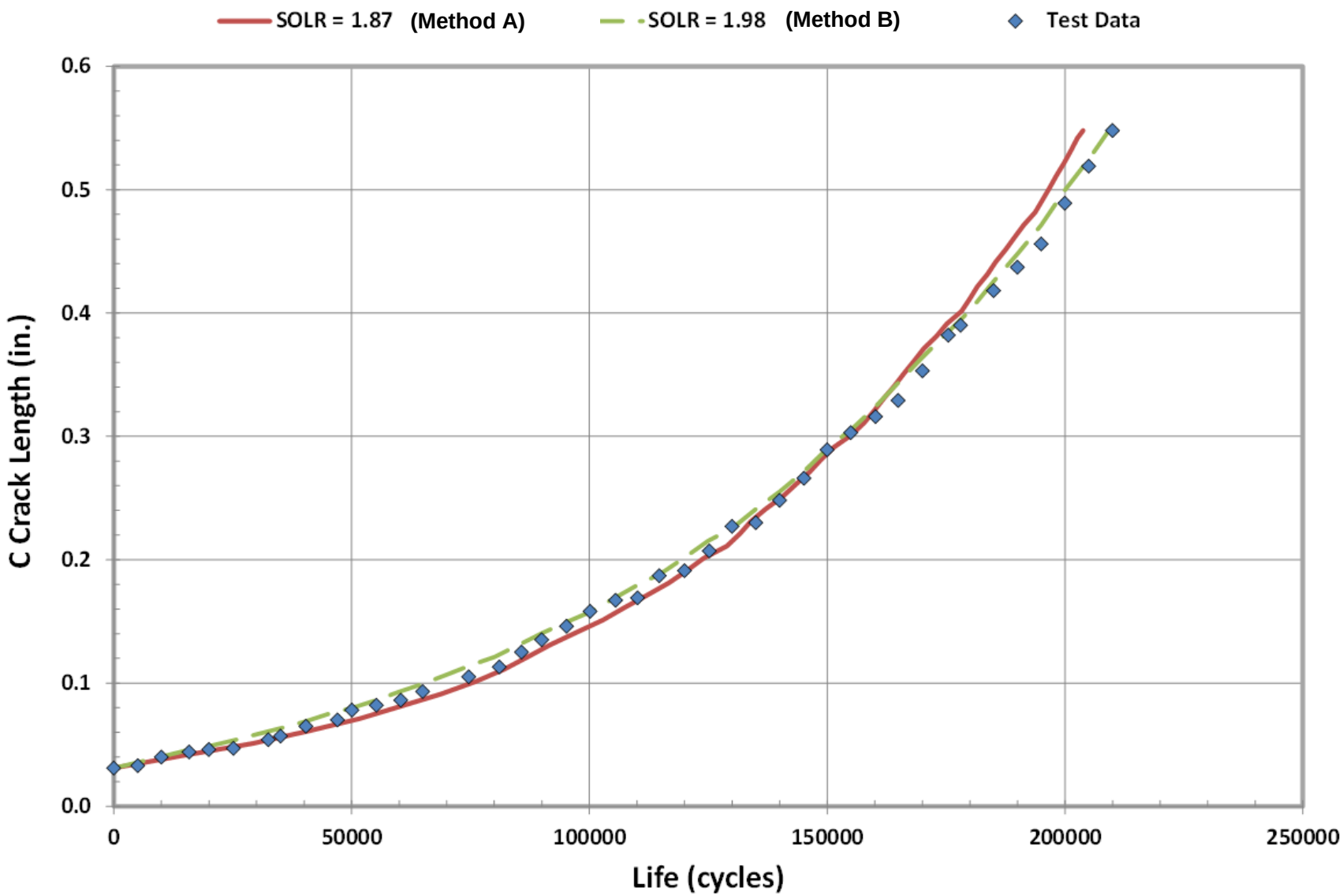
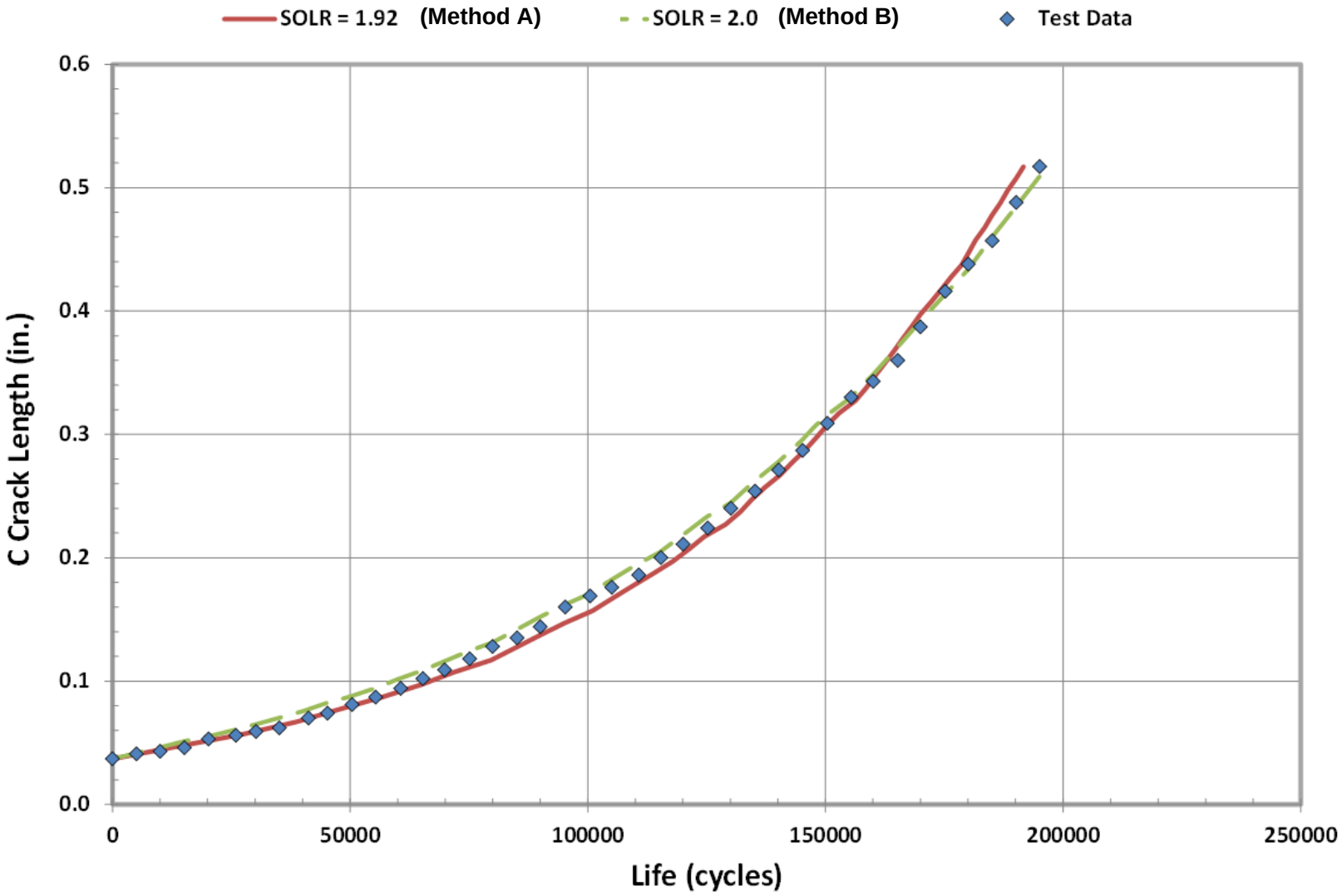
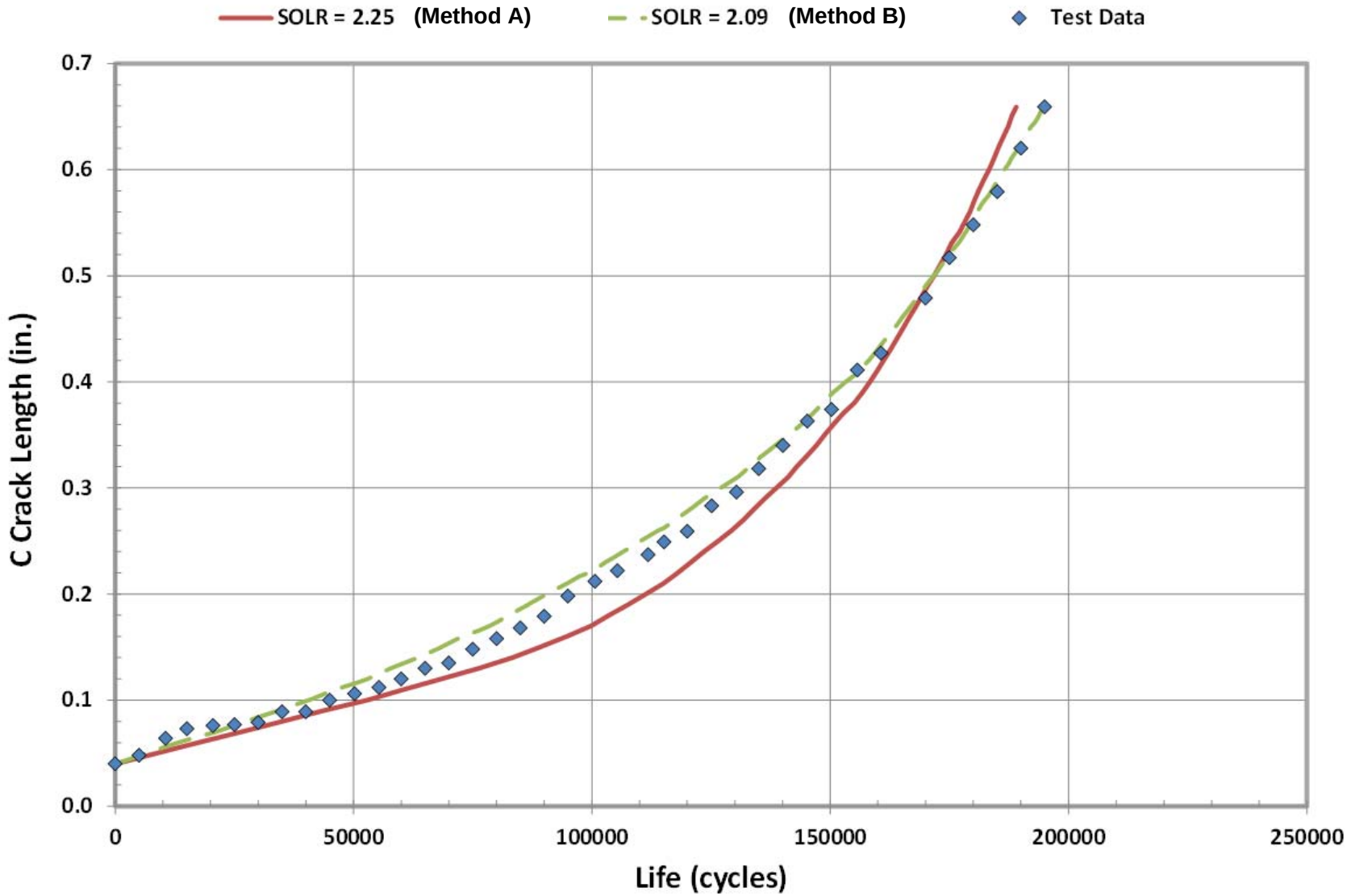


3/8-inch Specimen #3



5/8-inch Specimen #1



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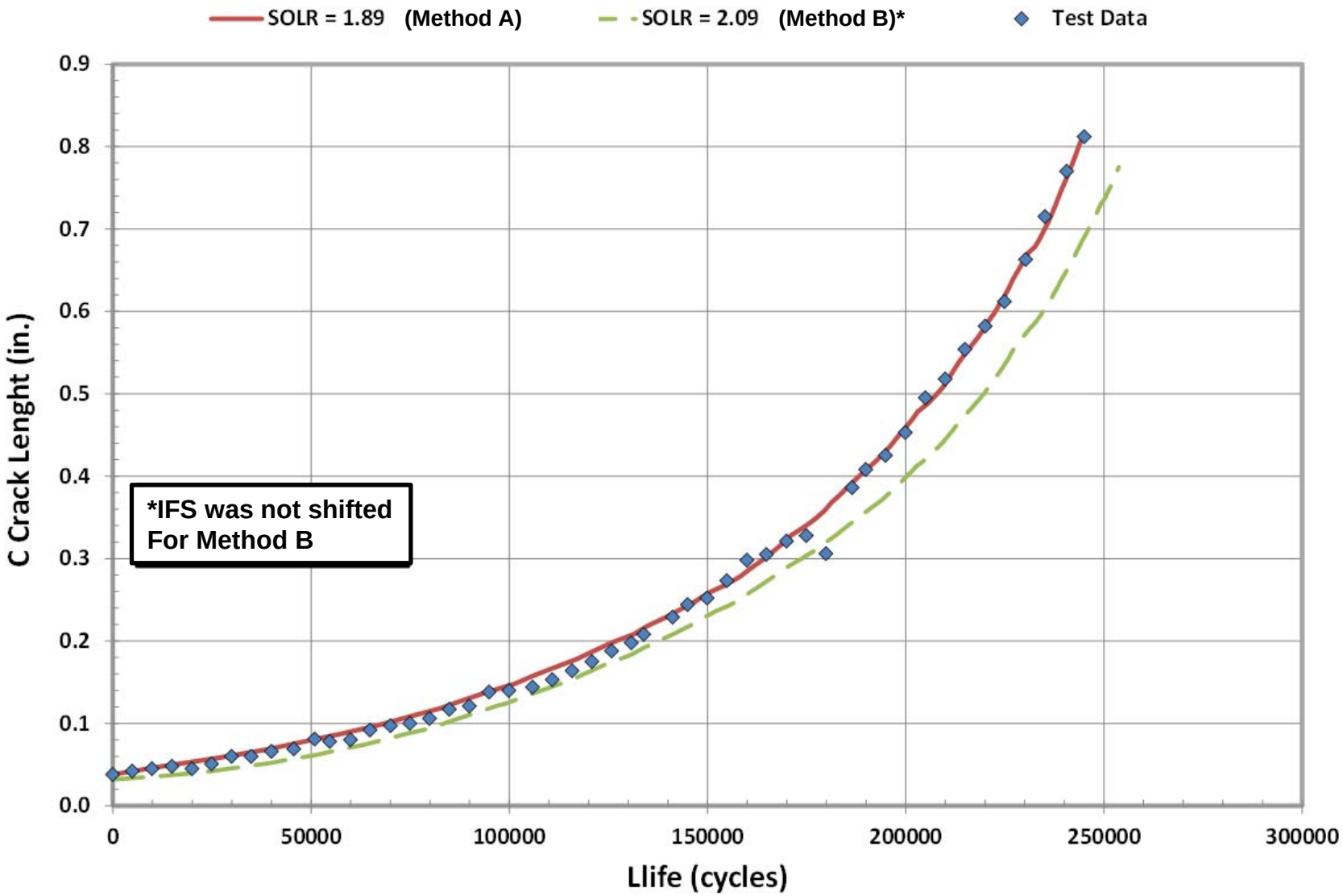
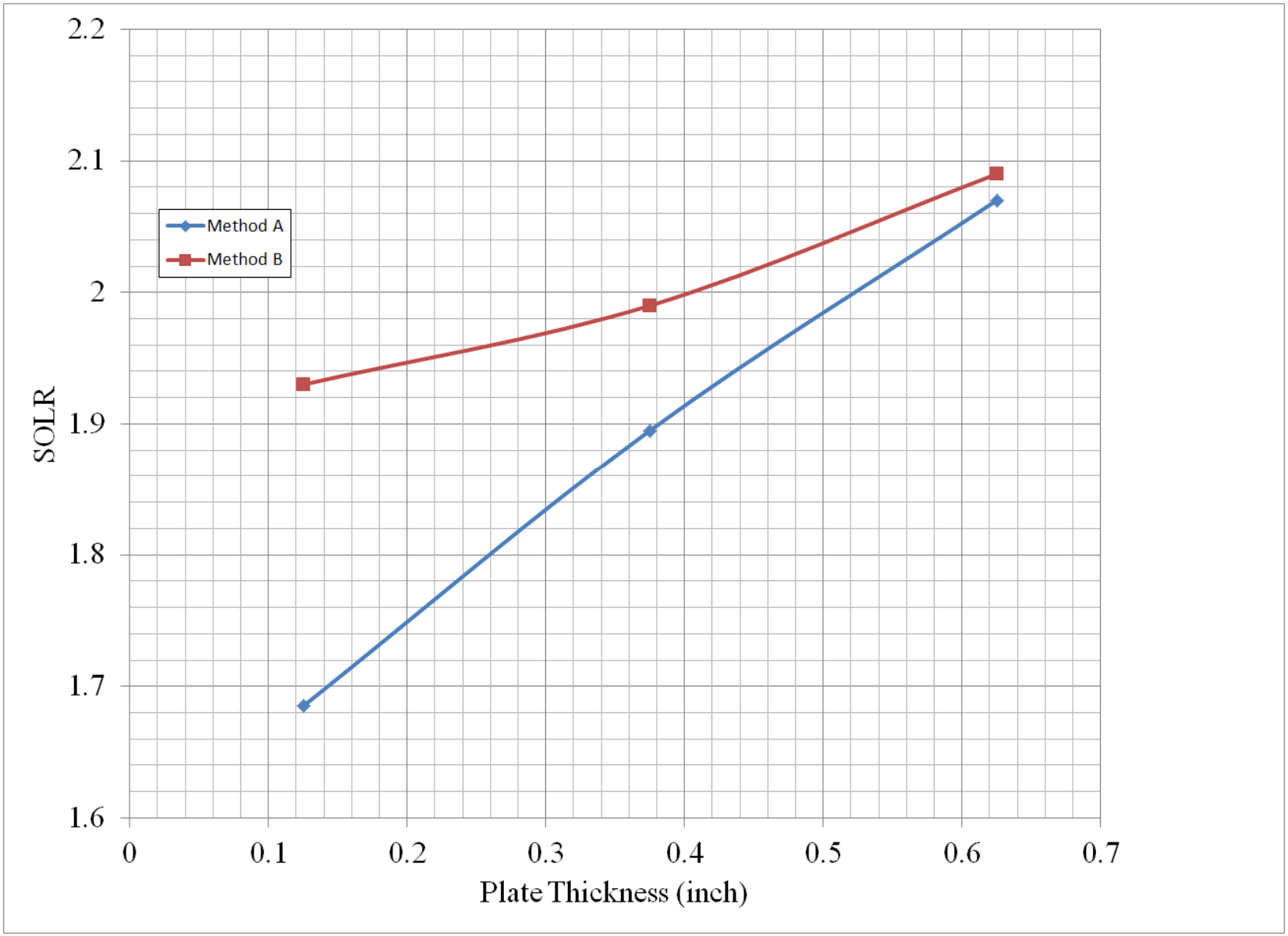


Summary of Results

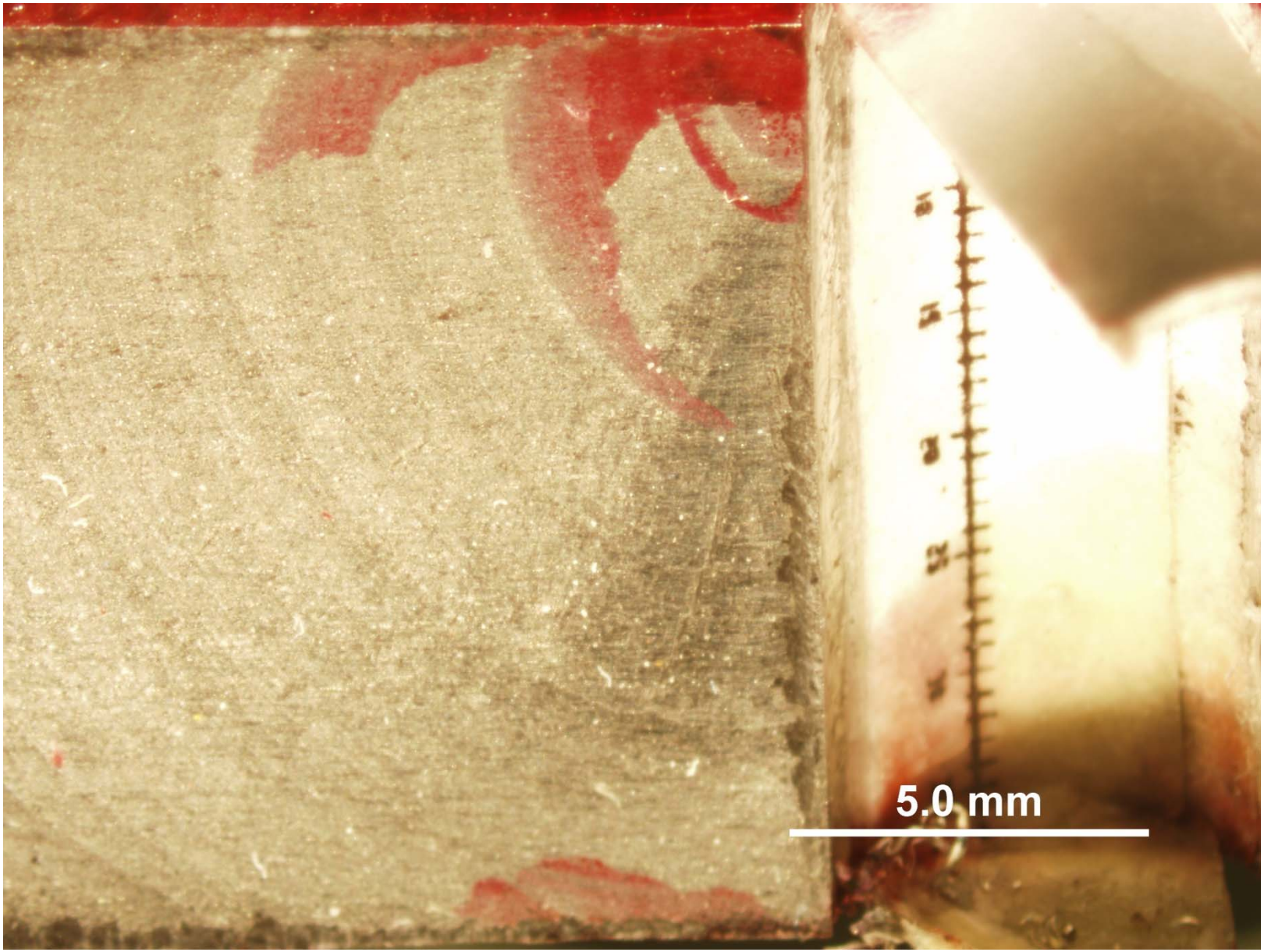
Specimen	SOLR			
	Method A	Average	Method B	Average
0.125 #1	1.67	1.685	1.93	1.93
0.125 #2	1.70		1.93	
0.375 #2	1.87	1.895	1.98	1.99
0.375 #3	1.92		2.00	
0.625 #1	2.25	2.07	2.09	2.09
0.625 #2	1.89		2.09	

SOLR vs. Plate Thickness

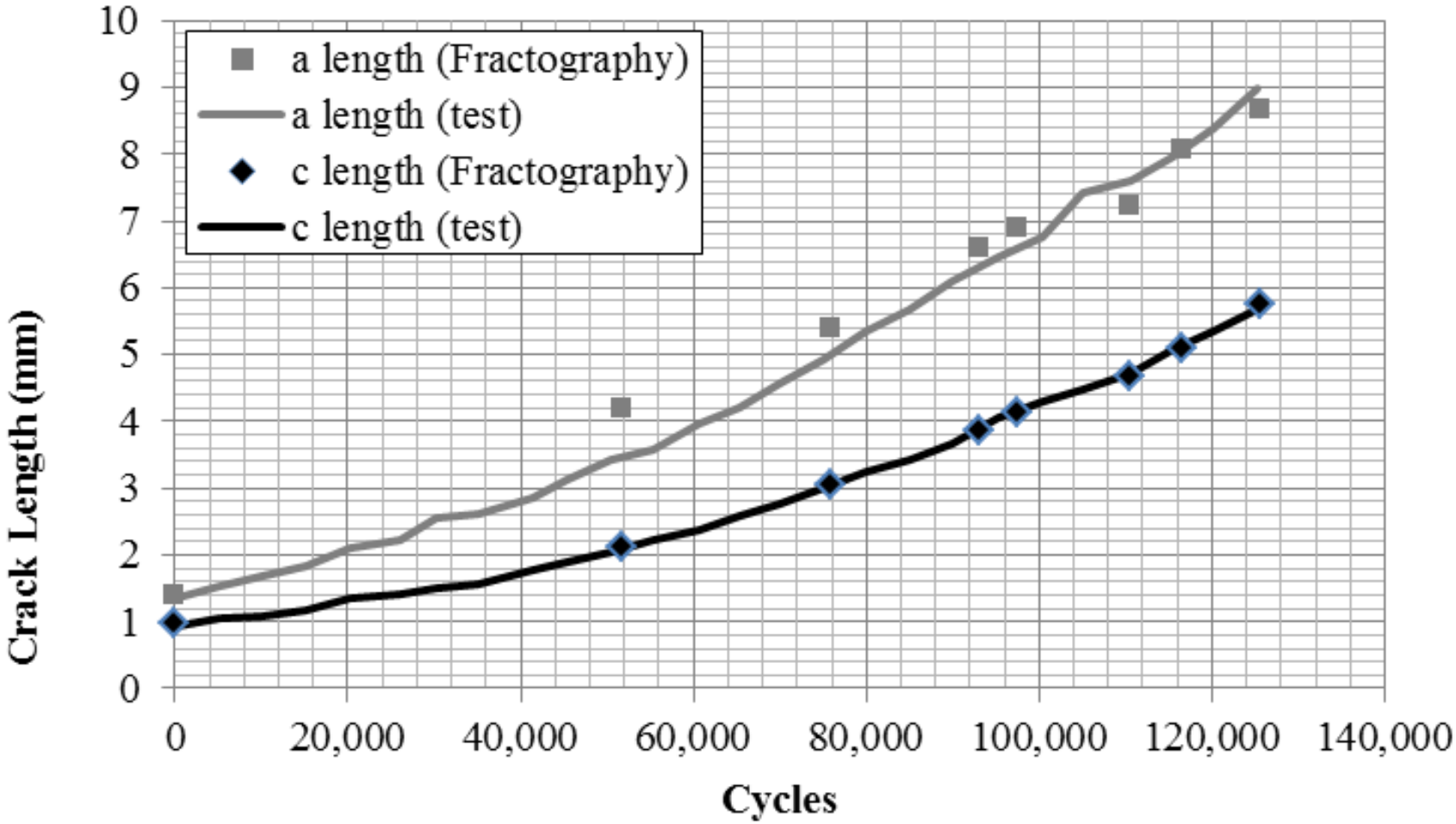


POST-TEST FRACTOGRAPHY

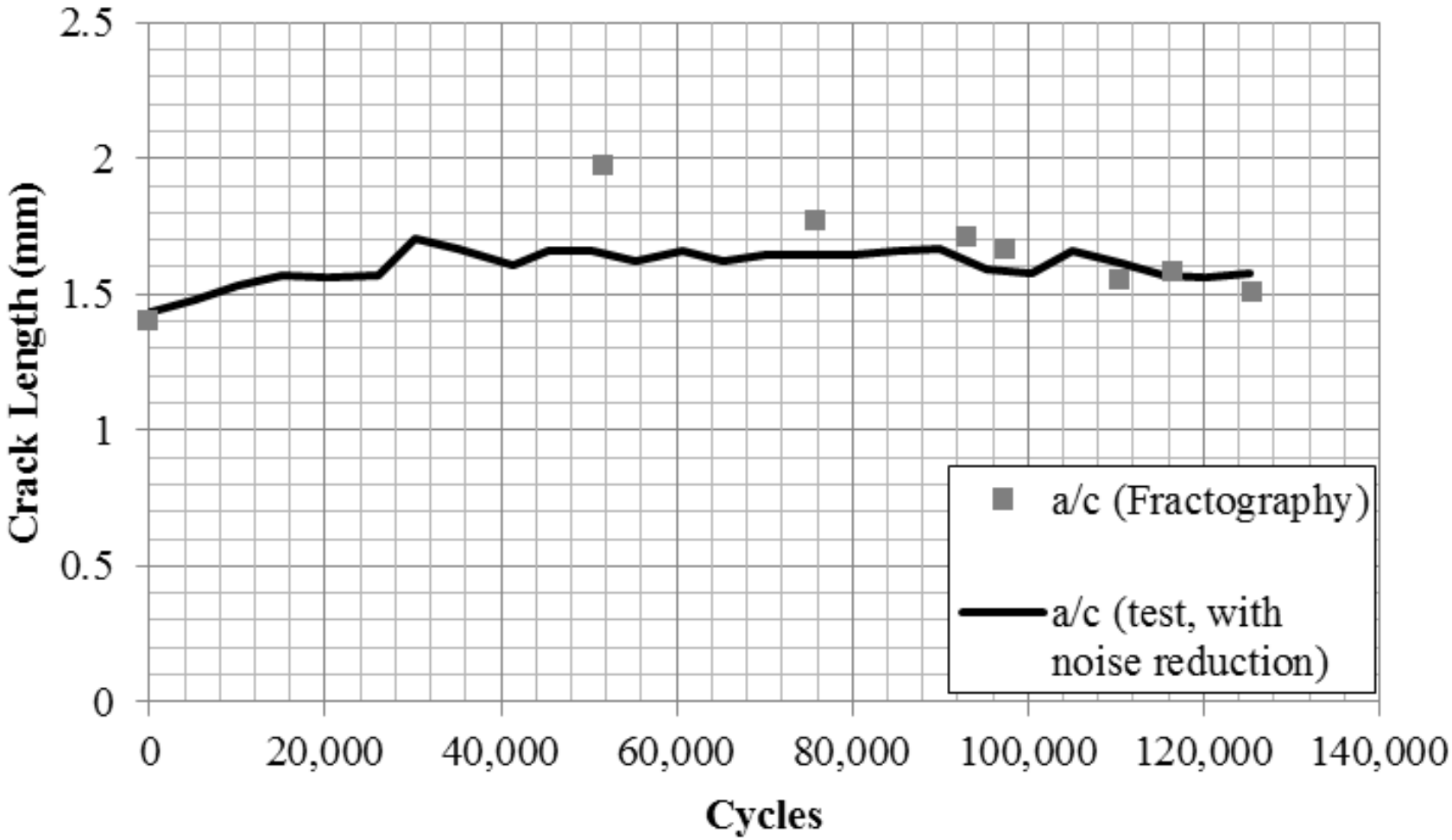
5/8-inch Thick Specimen #1



3/8-inch Specimen #2



3/8-inch Specimen #2



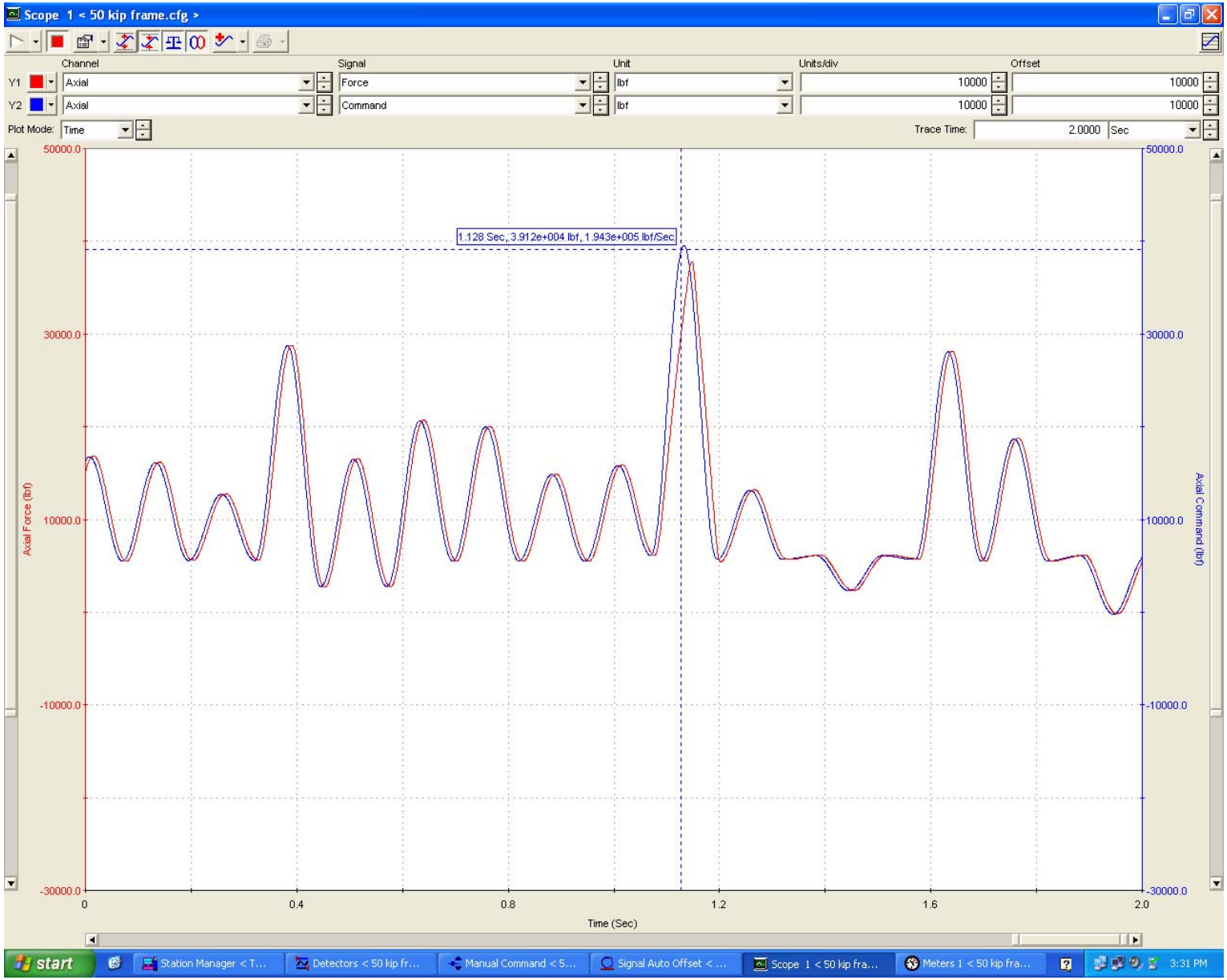
Observations and Trends

- **In general the (*c*-crack) *a* vs. *N* curve shape generated by AFGROW matched the shape of the experimental test data well---except for the 1/8-inch thick specimens, in which case the AFGROW simulation showed faster crack growth at long crack lengths**
- **Under Method B, the *a*-crack always grew faster than the AFGROW simulation**
- **Both methods show a trend of increasing SOLR with increasing thickness**
- **There is a more pronounced trend with Method A**

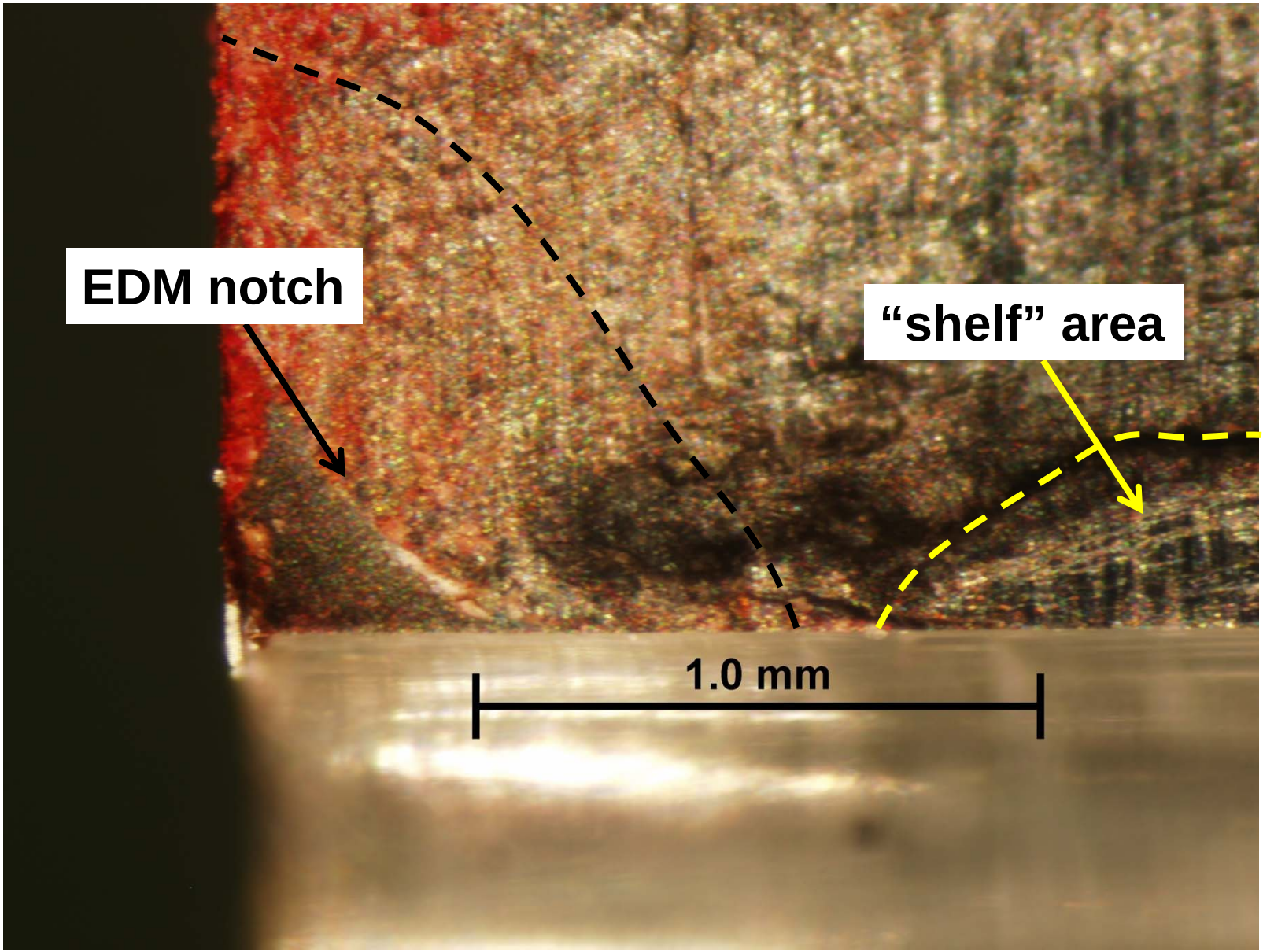
Issues

- Insufficient bore measurement frequency (first test)
- Machine tuning / missed load peaks (one test)
- Bore crack plane changes made measurements difficult or erroneous
  - Measuring bore cracks is hard
  - Experience matters
  - Bore polishing would likely help

Load Undershoot



EDM Notch; 1/8-inch Thick #1



Questions?